

**Laboratory Environment Safety and Health Committee  
Cryogenic Safety Subcommittee**

**MINUTES OF MEETING 05-07**

**August 16 and 23, 2005**

**Final**

**Committee Members Present**

W. Glenn<sup>1, 2</sup>  
S. Kane<sup>1</sup>  
E. Lessard (Chairperson)<sup>1, 2</sup>  
P. Mortazavi<sup>1</sup>  
M. Rehak<sup>1</sup>  
R. Travis (Secretary)<sup>1, 2, 3</sup>  
K. C. Wu<sup>1</sup>

**Committee Members Absent**

R. Alforque  
A. Sidi-Yekhlef

**Visitors**

J. Durnan<sup>3</sup>  
J. Tarpinian

**Agenda:**

- 1. Review of the Draft Cryogenic Safety Subject Area**
- 2. Review of the Draft Committee Guidelines Procedure**

**Minutes of Meeting:** Appended on pages 2 through 4.

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<b>E. Lessard</b>	<b>Date</b>
<b>LESHC Chairperson</b>	

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<b>J. Tarpinian</b>	<b>Date</b>
<b>ESH&amp;Q ALD</b>	

**DM2120.**

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<sup>1</sup> Present at the 8/16 Session.

<sup>2</sup> Present at the 8/23 Session.

<sup>3</sup> Designated as an ad hoc member for this meeting.

Chairperson E. Lessard called the first session of this meeting of the Laboratory Environmental Safety and Health Committee (LESHC) to order on August 16, 2005 at 1:40 p.m.

1. **Review of the Draft Cryogenic Safety Subject Area:** E. Lessard invited Subject Matter Expert Jim Durnan of the Safety and Health Services Division, to discuss the new Cryogenic Safety Subject Area.
  - 1.1. The following major Subject Area topics were discussed:
    - 1.1.1. The Cryogenic Safety SA is essentially an update and reformatting of the legacy ESH Standards, 5.1.0, “Non Flammable Cryogenic Liquids” and 5.2.0, “Flammable Cryogenic Liquids”.
    - 1.1.2. Section 1, “Using and Designing Cryogenic Systems”
      - 1.1.2.1. Irradiated cryogens can produce ozone, nitrous oxide or other explosive materials. For example, there can be trace amounts of dissolved oxygen in liquid nitrogen. Irradiation can convert this oxygen to solid ozone crystals. This phenomenon needs to be addressed in the Subject Area (SA).
      - 1.1.2.2. In an 8/17/05 followup email, the LESHC Chair provided several references on ozone explosions in irradiated cryogenic fluids for incorporation into the Subject Area.
      - 1.1.2.3. The purpose of, and the need for, cryogenic dewar logbooks were discussed at length.
        - 1.1.2.3.1. The committee noted that in the event of a plug, it is useful to know what amount of cryogen is in the dewar. This information can help determine the response to a plugged dewar.
        - 1.1.2.3.2. In addition, a written fill record can indicate higher than normal boil off rates and impending problems with the insulating vacuum
        - 1.1.2.3.3. The Committee consensus was that the logbook requirement (or an equivalent method to monitor inventory and losses) should be retained in the Subject Area.
      - 1.1.2.4. The “Plugged Dewars” Exhibit refers to “trained individuals”, which implies a formal training is provided to personnel who are authorized to remove plugs. This was clarified to refer to “qualified individuals” to more accurately reflect that this is an experience or knowledge based skill.
    - 1.1.3. Section 2, “Cryogenic Safety Review”
      - 1.1.3.1. There was significant discussion about the kinds of cryogenic activities that should require Committee review. Based on input offered at the meeting, the Subject Area will be revised to require LESHC review of all cryogenic systems/components, with the exception of in-kind replacements and the purchase of commercial storage dewars. This is consistent with the requirements of LESHC 1.0 (Draft 4.0B), “Guidelines and R2A2s for the Laboratory Environmental, Safety and Health Committee”. (See also 2. below.)

- 1.1.3.2. The information requirements specified in the Guidelines Procedure (such as the Hazard Identification Tool, equipment descriptions and, training requirements and status) will be added to the Subject Area.
- 1.1.4. Due to time constraints, the review of the remainder of the Subject Area, as well as the discussion of the Committee Guidelines Procedure was deferred to a second session.
- 1.1.5. Session 2 of this meeting commenced at 1:45 pm on August 23, 2005.
- 1.1.6. Sections 3 and 4, “Flammable Cryogenics” and “Using Liquid Oxygen” were discussed at length. Since liquid oxygen or flammable cryogenics have not been used at BNL in quite some time, there was limited Committee experience with these materials. The LESHC Chairperson requested additional input from other knowledgeable individuals. Al Pendzick provided input to the Chair which was included in the meeting discussion and these minutes
  - 1.1.6.1. The Subject Area reflects the legacy ESH Standard 5.2.0, “Flammable Cryogenic Liquids” which has not been substantively updated in quite some time. For example, Section 3 of the Subject Area is based on the use of dewars to store liquid hydrogen, however, the current technology would perhaps use a refrigerator to generate this flammable cryogen. Relevant Codes and Standard (e.g. NFPA 50B) can also be expected to have changed to reflect the current state of the art.
  - 1.1.6.2. The use of flammable cryogenics or liquid oxygen at BNL is not anticipated in the foreseeable future. It is likely that any changes that could be made to the current Subject Area would be outdated before an application arose at BNL.
  - 1.1.6.3. The Committee requested that a note be inserted into Sections 3 and 4 to require re-evaluation of the SA requirements prior to designing or installing a new flammable cryogen or liquid oxygen system at BNL.
- 1.1.7. ADDENDUM: All Committee comments were satisfactorily incorporated into the Cryogenic Safety Subject Area (Reference: 9/21/05 E. Lessard email.)

## 2. Draft Committee Guidelines Procedure

- 2.1. Due to time constraints, Committee discussion on the LESHC 1.0 (Draft 4.0B), “Guidelines and R2A2s for the Laboratory Environmental, Safety and Health Committee” was curtailed.
- 2.2. The Chair, however, provided written comments on the Guidelines document. The comments were primarily of an editorial nature, including procedure formatting requirements and, removal of the documentation submittal requirements, which were added to the Cryogenic Safety Subject Area. (See 1.1.3.2 above.)
- 2.3. The Secretary committed to update the procedure to Draft 5.0 and issue it for final review by the full Committee, the ESHQ ALD and other interested parties.

3. The Meeting was adjourned at 3:20 p.m.

Management System: [Worker Safety and Health](#)

Subject Area: [Cryogenics Safety](#)

# Operating Instructions for Liquid Nitrogen Buggies

Effective Date:

Follow these instructions when operating portable liquid nitrogen (LN2) storage dewars (Buggies).

**Note: A copy of the operating instructions must be mounted on each buggy.**

## Liquid Withdrawal

Since liquid withdrawal is from the bottom, liquid can be withdrawn from full to about half-full without the use of pressure building coil.

Connect a suitable hose to fill drain connection (C-2) and open liquid valve (V-1) slowly to start withdrawal. *What is a suitable hose? Is there a particular hose to use?*

## Pressurized Liquid Withdrawal

1. Close vent valve (V-3).
2. Open pressure build-up valve (V-2). Allow pressure to build to 10-20 psig.
3. Close pressure build-up valve (V-2).
4. Open liquid valve (V-1) to remove liquid.
5. When filling is complete, close liquid valve (V-1).
6. Open vent valve (V-3) to vent dewar.

## Caution

When dewar is not in use, the dewar vent valve (V-3) must be left open.

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Management System: [Worker Safety and Health](#)

Subject Area: [Cryogenics Safety](#)

# Liquid Oxygen and Flammable Cryogenics Safety Requirements

Effective Date:

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## OPERATING REGULATIONS FOR LIQUID OXYGEN

### A. General Precautions for Liquid Oxygen Areas (LOX):

1. Liquid oxygen should be handled and used only by persons trained in the nature of the material.
2. LOX should be transported only in suitable containers which will permit the escape of vapors. Fire, sparks, and other sources of ignition should be kept away from the area exposed to the vapors. Concentration of the vapors should be prevented by ample ventilation.
3. LOX has a much greater capacity to support combustion than has air. Porous organic materials, such as clothing or wood, may retain oxygen for a considerable time. Do not expose them to any source of ignition because they can burn violently. Mixtures of organic materials and LOX, under certain conditions, may detonate. Certain inorganic structural materials in contact with LOX can reduce the safety of the apparatus.
4. Before introducing LOX into a system, take special precautions to ensure that all contaminants have been removed. Refer to Compressed Gas Association Pamphlet, G-4.1 "Cleaning Equipment for Oxygen Service."
5. Identify all potential ignition sources. Electrical equipment must meet the same explosion-proof requirements as those for LH2.
6. Use oxygen analyzers or checking oxygen concentration and detecting leaks.

### B. Equipment

All equipment designed for using LOX must not have any materials of the type mentioned in A.1 above in contact with LOX. The equipment must be electrically grounded. Any dewar or transfer device must then be electrically grounded to the equipment before transfer. First electrical contact with any LOX container must be made away from any vent opening.

## GENERAL PRECAUTIONS FOR FLAMMABLE CYROGENIC AREAS

All storage tanks, portable dewars, equipment, and systems used in handling liquid hydrogen must meet the requirements of National Fire Protection Association Standard No. 50B, "Liquefied Hydrogen Systems at Consumer Sites." All installations must meet the requirements of [ESH Standard 4.11.0 Installation of Flammable Gas Systems \(Experimental and Temporary Installations\)](#) and [ESH Standard 4.12.0 Special Precautions for Locations Containing Flammable Atmospheres](#).

### A. Liquid Hydrogen Area Safety

1. Venting to atmosphere must never be within a building but must be via piping to the outside. Normal boil-off venting systems upstream of pressure relief devices must be maintained at pressures slightly above atmospheric to minimize infiltration of air. Emergency venting systems need not meet this requirement but must be separate from the normal venting (boil-off) systems. Liquid hydrogen must not be used in nonventilated spaces. Positive airflow must be maintained to ensure adequate air change minimizing stagnation or collection within the space.
2. Identify and eliminate potential ignition sources. No smoking or open flames within a radius of 50 feet is permitted.
3. Use portable combustible gas detectors for checking points not readily accessible or not monitored by stationary sampling heads.

### B. Building Requirements

1. The building or room in which LH2 is to be used must meet the electrical safety design requirements outlined in OH&S Guide 4.12.0, "Locations Containing Flammable Atmospheres."
2. When a temporary structure, such as a tent, is installed inside of a building to enclose LH2 equipment, that enclosure must be continuously monitored by a combustible gas detector system. In the event of gas detection (at 25% of LEL), local audible alarms, remote watch station alarm indication, increased air-flow ventilation, and the de-energizing of any ignition sources must be initiated automatically. The emergency systems must all be tested before startup and must be in proper operating condition when LH2 is being used. The detecting system must have the capability of being checked from outside the enclosure and holding a calibration of 25% of the LEL (LEL of hydrogen gas is 4%).
3. The area within a radius of 10 feet of LH2 equipment must be kept free of combustible materials. In particular, solvents and other flammable fluids must be properly stored away from the equipment.
4. The area must have limited access, and signs indicating hydrogen is in use must be prominently displayed. Exclude all unauthorized persons from the area.

5. The safest route for moving dewars between the LH2 dewar enclosure and a building exit must be clearly marked and kept free of obstructions. An additional route for personnel access and egress must be provided.

## C. Equipment

1. All equipment designed for liquid H<sub>2</sub>, except certain dewars, must have a normal boil-off vent and an emergency vent. Normal boil-off vents must be maintained at slightly above atmospheric pressure to prevent back diffusion of air and plugs in the vent. The emergency vent must contain a positive pressure relief device that prevents rupture of the LH<sub>2</sub> container. Vacuum-insulated equipment and pumps must be provided with pressure reliefs that are vented to the outdoors.
2. All controls must be connected to an emergency power circuit.
3. The equipment must be electrically grounded. Any dewar or transfer device must then be electrically bonded to the equipment before transfer. First electrical contact with an H<sub>2</sub> container must be made away from any vent opening.
4. Dewars must be protected from back diffusion and plugs by a check valve or other devices, which will ensure a slight positive pressure in the vent spaces. They must be connected to a normal boil-off vent to the outdoors when not connected to equipment. They must be checked daily to ensure proper venting. Openmouthed and/or glass dewars must not be used.
5. Materials susceptible to hydrogen attack and hydrogen embrittlement must not be used in hydrogen service. Materials that should be avoided include the following:
  - Titanium;
  - Maraging steels;
  - SA-517 (or similar heat-treated steels);
  - Series 400 Stainless steels;
  - MIL-S-16216, and precipitation-hardened stainless steels.

**(Note:** See NSS 1740.16, "NASA Safety Standard for Hydrogen and Hydrogen Systems" for more information on hydrogen service.

## D. Operation of Equipment

1. Unless specifically exempted by the Laboratory Environmental, Safety and Health Committee (LESH), equipment containing LH<sub>2</sub> must be monitored by at least one qualified operator while the equipment has any liquid or gas in it, and until it has been completely emptied and purged. The operator must be able to communicate with the shift supervisor or Department/Division representative having emergency responsibilities.
2. A person is designated a qualified cryogenic equipment operator by the person's supervisor upon completion of required training and after demonstrating the capability of safe system operation. Some of the areas of knowledge required before designation are

- a. Properties and hazards of liquefied gases;
  - b. Equipment safety systems;
  - c. Building safety systems;
  - d. Appropriate BNL requirements;
  - e. Local departmental operating and safety procedures.
3. Before introducing H<sub>2</sub> into any system, the system must be purged with inert gas and/or evacuated to remove air. This must be repeated to ensure that no explosive mixture remains. When it is necessary to open the system to atmosphere, it must first be purged to ensure that the resulting H<sub>2</sub>-air concentration is less than 1% H<sub>2</sub>. Detailed procedures for purging will differ with different systems.

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Management System: [Worker Safety and Health](#)

Subject Area: [Cryogenics Safety](#)

# Characteristics of Cryogenics

Effective Date:

Characteristics of Cryogenic Fluids					
Fluid	Boiling Point				Volume Expansion to Gas <sup>a</sup>
	°K	°R	°C	°F	
Helium-3	3.2	5.8	-269.9	-453.9	757 to 1
Helium-4	4.2	7.6	-268.9	-452.1	757 to 1
Hydrogen <sup>F</sup>	20.4	36.7	-252.7	-423.0	851 to 1
Deuterium <sup>F/R</sup>	23.6	42.5	-249.5	-417.2	...
Tritium <sup>F/R</sup>	25.1	45.2	-248.0	-414.5	...
Neon	27.2	49.0	-245.9	-410.7	1438 to 1
Nitrogen	77.3	139.1	-195.8	-320.5	696 to 1
Carbon monoxide <sup>F/T</sup>	81.1	146.0	-192.0	-313.7	...
Fluorine <sup>T</sup>	86.0	154.8	-187.2	-304.9	888 to 1
Argon	87.4	157.3	-185.7	-302.4	847 to 1
Oxygen	90.1	162.2	-183.0	-297.5	860 to 1
Methane <sup>F</sup>	111.7	201.1	-161.4	-258.6	578 to 1
Krypton	121.3	218.3	-151.8	-241.3	700 to 1
Tetrafluoromethane <sup>T</sup>	145.0	261.0	-128.0	-198.7	...
Ozone <sup>F/T</sup>	161.3	290.3	-111.9	-169.3	...
Xenon	164.0	295.2	-109.1	-164.5	573 to 1
Ethylene <sup>F</sup>	169.3	304.7	-103.8	-154.9	...

Characteristics of Other Low Temperature Fluids					
Fluid	Boiling Point				Volume Expansion to Gas <sup>a</sup>
	°K	°R	°C	°F	
Boron trifluoride <sup>T</sup>	172.7	310.9	-100.3	-148.8	...
Nitrous oxide	183.6	330.5	-89.5	-129.2	666 to 1
Ethane <sup>F</sup>	184.8	332.6	-88.3	-127.0	...
Hydrogen chloride <sup>T</sup>	188.0	338.4	-85.0	-121.3	...
Acetylene <sup>F/R</sup>	189.1	340.4	-84.0	-119.3	...
Fluoroform	189.1	340.4	-84.0	-119.3	...
1,1-Difluoroethylene <sup>F/R</sup>	190.0	342.0	-83.0	-117.4	...
Chlorotrifluoromethane <sup>T</sup>	191.6	334.9	-81.4	-114.8	...
Carbon dioxide <sup>T</sup>	194.6	350.3	-78.5	-109.4	553 to 1

<sup>a</sup> - Expansion from liquid (boiling point) to room temperature (multiply by 1/28.3 to convert from liters to cubic feet)

F - Flammable

T - Toxic

R - Radioactive

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**Management System:** [Worker Safety and Health](#)**Subject Area:** [Cryogenics Safety](#)**4. Using Liquid Oxygen DRAFT**Effective Date: **Sep 9, 9999**

Last Modified: 06/09/2005

02:05:45 PM

Subject Matter Expert:

[Jim Durnan](#)

Management System Owner:

[James Tarpinian](#)[| SBMS Home Page](#) | [Top of Subject Area](#) | [Instructions](#) | [Definitions](#) |**Applicability**

This information applies to BNL staff and non-BNL staff doing work for BNL that will use liquid oxygen (LOX) at BNL.

**Required Procedure**

Liquid Oxygen (LOX) is inherently nonflammable, however, when combined with organic materials, energetic reactions can occur. Gaseous oxygen has a much greater capacity for supporting combustion than air. Therefore, in addition to the requirements of this section and the section [Designing and Using Cryogenics](#), a review by the Laboratory Environmental, Safety and Health Committee is required.

**Step 1**

The Principal Investigator/Cognizant Engineer informs the Laboratory Environmental, Safety and Health Committee (LESHC) Chairperson that the proposed design involves the use or storage of Liquid Oxygen (LOX) and needs to be reviewed.

**Note:** The LESHC must review all newly proposed LOX system designs for both the equipment design and the integration within a building or laboratory. When previously reviewed equipment is put back in service in the original or slightly modified condition, the review may be limited to an LESHC subcommittee.

<b>Step 2</b>	The Principal Investigator/Cognizant Engineer contacts the Emergency Services Division for an evaluation of the facility for Fire/Life Safety issues.
<b>Step 3</b>	<p>The LESHHC submits recommendations to the Assistant Laboratory Director for Environment, Safety, Health &amp; Quality (ESH&amp;Q) for approval.</p> <p>After the Assistant Laboratory Director for ESH&amp;Q approves the design/use, construction and installation are permitted.</p>
<b>Step 4</b>	The Building Manager reviews and changes the facility's safety documentation (Safety Assessment Document [SAD]/safety operating envelope, FUA).
<b>Step 5</b>	The Principal Investigator/Cognizant Engineer determines if an Operational Readiness Evaluation (ORE) is required. See the <a href="#">Operational Readiness Evaluation (ORE)</a> Subject Area for information.
<b>Step 6</b>	The Principal Investigator/Cognizant Engineer requests a review (including walk-through) by the appropriate safety committees of the completed installation before delivery of LOX.
<b>Step 7</b>	<p>The Department/Division ensures adequate provisions are established for delivery of LOX. These include</p> <ul style="list-style-type: none"> <li>• Deliveries must only be made to those areas designated by the LESHHC.</li> <li>• The appropriate supervisor must designate qualified staff to be available to receive, store, and dispense LOX.</li> </ul>
<b>Step 8</b>	<p>The Department/Division follows the <a href="#">Transfer of Hazardous Materials Onsite</a> Subject Area for transferring LOX over Laboratory roads.</p> <p><b>Note:</b> The specific requirements of the <a href="#">BNL On-site Transfer/Safety Assessment Form</a> must be followed. If container pressure cannot exceed 23.3 psig and the volume is 4 liter or less, than LOX transportation can be considered as Material of Trade.</p>

## References

[Operational Readiness Evaluation \(ORE\)](#) Subject Area

[Transfer of Hazardous Materials Onsite](#) Subject Area

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**Management System:** [Worker Safety and Health](#)**Subject Area:** [Cryogenics Safety](#)**3. Flammable Cryogenics DRAFT**

Effective Date: **Sep 9, 9999**  
Last Modified: 06/09/2005  
02:53:09 PM

Subject Matter Expert:  
[Jim Durnan](#)

Management System Owner:  
[James Tarpinian](#)

| [SBMS Home Page](#) | [Top of Subject Area](#) | [Instructions](#) | [Definitions](#) |

## Applicability

This information applies to BNL staff and non-BNL staff doing work for BNL that will use or transport flammable cryogenic fluids, which includes liquid hydrogen (LH2) and liquid deuterium.

## Required Procedure

In addition to the hazards associated with cryogenics, these fluids in their gaseous state exhibit extremely high-fire and explosion hazards. Gaseous hydrogen can form an explosive mixture over a range of 4 to 75% concentration in air.

The procedures below are used to minimize the possibility of fire or explosion resulting from the use of flammable cryogenics.

In addition to all the requirements of the sections [Using and Designing Cryogenics](#) and [Cryogenic Safety Review](#), the following requirements must be followed:

<b>Step 1</b>	<p>The Principal Investigator/Cognizant Engineer</p> <ul style="list-style-type: none"> <li>• Informs the Laboratory Environmental, Safety and Health Committee (LESHC) Chairperson that the proposed design involves the use or storage of flammable cryogenic fluids and needs to be reviewed;</li> <li>• Requests an LESHC meeting (See the section <a href="#">Cryogenic Safety Review</a>).</li> </ul> <p><b>Note:</b> The LESHC must review all newly proposed flammable cryogenic fluids system designs for both the equipment design and the integration within a building or laboratory. When equipment previously reviewed is put back in service in the original or slightly modified condition, the review may be limited to an LESHC subcommittee.</p>
<b>Step 2</b>	<p>The Principal Investigator/Cognizant Engineer</p> <ul style="list-style-type: none"> <li>• Informs the Emergency Services Division of the proposed design and storage requirements for flammable cryogenic fluids. The Emergency Services Division evaluates the facility for Fire/Life Safety issues.</li> </ul>
<b>Step 3</b>	<p>The LESHC submits recommendations, including Emergency Services Division evaluation, to the Assistant Laboratory Director, Environment, Safety, Health and Quality (ESH&amp;Q) for approval.</p> <p>After the Assistant Laboratory Director for ESH&amp;Q approves the design and use, construction and installation are permitted.</p>
<b>Step 4</b>	<p>The Building Manager reviews and changes the facility's safety documentation (SAD/ safety operating envelope/FUA).</p>
<b>Step 5</b>	<p>The Project Leader or Principal Investigator determines if an Operational Readiness Evaluation (ORE) is required. See the <a href="#">Operational Readiness Evaluation (ORE)</a> Subject Area for information.</p>

<b>Step 6</b>	<p>The Responsible Person in the Department/Division requests a review (including walk-through) by the appropriate safety committees before the admission of flammable cryogenics. These committees may include the</p> <ul style="list-style-type: none"> <li>• Accelerator Safety Committee;</li> <li>• Experimental Safety Committee;</li> <li>• Laboratory Environmental, Safety and Health Committee.</li> </ul>
<b>Step 7</b>	<p>The Department/Division ensures adequate provisions are established for delivery of flammable cryogenic fluids. These include</p> <ul style="list-style-type: none"> <li>• Deliveries only to areas designated by the LESHG;</li> <li>• The appropriate supervisor designates qualified staff to receive, store, and dispense flammable cryogenic fluids;</li> <li>• Liquid H<sub>2</sub> must be transported only in containers designed for the purpose. These containers must be clearly marked "Hydrogen Flammable;"</li> <li>• All liquid H<sub>2</sub> trailers must be provided with "Hydrogen Flammable" marking, reflectors, and safety tow chains, and be properly secured;</li> <li>• Equipment used for storage and delivery of liquid H<sub>2</sub> must be maintained by the authorized personnel.</li> </ul> <p><b>Note:</b> To ensure the liquid hydrogen delivered to BNL is sufficiently pure to be used safely, the vendor certifies the contents of all shipments to meet the specification of MIL-P-27201 (Propellant, Hydrogen), DOD-1971 (Liquid Propellant Fuels and Oxidizers, Chemical Base).</p>
<b>Step 8</b>	<p>The Department/Division follows the <a href="#">Transfer of Hazardous Materials Onsite</a> Subject Area for transferring flammable cryogenics over Laboratory roads.</p> <p><b>Note:</b> The specific requirements of the <a href="#">BNL On-site Transfer/Safety Assessment Form</a> must be followed. If container pressure cannot exceed 23.3 psig and the volume is 4 liter or less, than transportation can be considered as Material of Trade.</p>
<b>Step 9</b>	<p>The Department/Division ensures all storage tanks, portable dewars, equipment and systems used in handling liquid hydrogen meet the requirements of National Fire Protection Association Standard NFPA 50B, "Liquefied Hydrogen Systems at Consumer Sites."</p>

<b>Step 10</b>	<p>Venting to atmosphere must be via piping to the outside, never within a building.</p> <ul style="list-style-type: none"><li>● Maintain normal boil-off venting systems upstream of pressure relief devices at pressures slightly above atmospheric to minimize infiltration of air. Emergency venting systems need not meet this requirement but must be separate from the normal venting (boil-off) systems;</li><li>● Do not use liquid hydrogen in unvented spaces. Maintain positive air flow to ensure adequate air-change minimizing stagnation or collection within the space.</li></ul>
<b>Step 11</b>	<p>Use portable combustible gas detectors for checking points not readily accessible or not monitored by stationary sampling heads.</p> <p>When a temporary structure, such as a tent, is installed inside of a building to enclose flammable cryogenic equipment, that enclosure must be continuously monitored by a combustible gas detector system. If gas is detected (at 10% of LEL), local audible alarms, remote watch station alarms, increased air-flow ventilation, and the de-energizing of any ignition sources are initiated automatically.</p> <p><b>Note:</b> The emergency systems must all be tested before start-up and must be in proper operating condition when LH<sub>2</sub> is being used. The detecting system must be capable of being checked from outside the enclosure and holding a calibration of 10% of the LEL (LEL of hydrogen gas is 4%).</p>
<b>Step 12</b>	<p>Keep the area within a radius of 10 ft of flammable cryogenic equipment free of combustible materials. In particular, store solvents and other flammable fluids away from the equipment.</p> <ul style="list-style-type: none"><li>● Exclude all unauthorized persons from the area. The area must have limited access. Prominently post signs indicating flammable cryogen is in use;</li><li>● Clearly mark the safest route for moving dewars between the enclosure and a building exit. Keep it free of obstructions. Provide an additional route for personnel access and egress.</li></ul>

<b>Step 13</b>	<p>All equipment designed for flammable cryogenics (except certain dewars) must have a normal boil-off vent and an emergency vent.</p> <ul style="list-style-type: none"> <li>● Maintain normal boil-off vents at slightly above atmospheric pressure to prevent back diffusion of air and plugs in the vent. The emergency vent must contain a positive pressure relief device to prevent rupture of the LH2 container;</li> <li>● Vacuum-insulated equipment and pumps must be provided with pressure reliefs that are vented to the outdoors.</li> </ul>
<b>Step 14</b>	<p>Ensure all controls are connected to an emergency power circuit.</p>
<b>Step 15</b>	<p>Ensure the equipment is electrically grounded. Any dewar or transfer device must then be electrically bonded to the equipment before transfer. Make sure first electrical contact with an H2 container is made away from any vent opening.</p>
<b>Step 16</b>	<p>Protect dewars from back diffusion and plugs by a check valve or other devices, which will ensure a slight positive pressure in the vent spaces.</p> <ul style="list-style-type: none"> <li>● Connect the dewars to a normal boil-off vent to the outdoors, when not connected to equipment;</li> <li>● Check them daily to ensure proper venting;</li> <li>● Do not use openmouthed and/or glass dewars.</li> </ul>
<b>Step 17</b>	<p>Unless specifically exempted by the LESH, at least one qualified operator must monitor the equipment while it has any liquid or gas in it, and until it has been completely emptied and purged. The operator must be able to communicate with the shift supervisor or department representative having emergency responsibilities.</p> <p><b>Note:</b> A person is designated a qualified cryogenic equipment operator by the person's supervisor upon completion of required training and after demonstrating the capability of safe system operation. Some of the areas of knowledge required before designation are: Properties and hazards of liquefied gases; Equipment safety systems; Building safety systems; Appropriate Guides in the BNL Safety Manual ; Local departmental operating and safety procedures.</p>

**Step 18**

Before introducing flammable cryogen into any system, either purge the system with inert gas or evacuate it to remove air. Repeat this to ensure that no explosive mixture remains. When it is necessary to open the system to atmosphere, first purge it to ensure that the resulting flammable cryogen-air concentration is less than 1%.

Detailed procedures for purging will differ with different systems. Department/Divisions may develop their own written procedures for this operation.

## References

National Fire Protection Association Standard N0. 50B, "Liquefied Hydrogen Systems at Consumer Sites"

[Operational Readiness Evaluation \(ORE\)](#) Subject Area

[Transfer of Hazardous Materials Onsite](#) Subject Area

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Filename: //sbms.bnl.gov/draft/subjarea/164/pro4.cfm Last Modified: 06/09/2005 02:53:09 PM

**Management System:** [Worker Safety and Health](#)

**Subject Area:** [Cryogenics Safety](#)

## 2. Cryogenic Safety Review **DRAFT**

Effective Date: **Sep 9, 9999**

Last Modified: 06/08/2005

02:49:57 PM

Subject Matter Expert:

[Jim Durnan](#)

Management System Owner:

[James Tarpinian](#)

| [SBMS Home Page](#) | [Top of Subject Area](#) | [Instructions](#) | [Definitions](#) |

### Applicability

This information applies to BNL staff and non-BNL staff doing work for BNL that will use cryogenic fluids and/or systems at BNL.

### Required Procedure

All uses of cryogenic fluids at BNL require a safety review. The rigor of the review and documentation will be commensurate with the level of hazard using the "graded approach." The Department/Division where the cryogens will be installed and used will start the safety review. This review may be included in an Experimental Safety Review, however if this is a new cryogenic system, custom-built cryogenic equipment, or the cryogenic system is designed, built or modified at BNL or by the experimenter's home institution, the Laboratory Environmental, Safety and Health Committee (LESHC) will perform the review.

<b>Step 1</b>	<p>The Principal Investigator/Cognizant Engineer informs the Department/Division that a cryogenic safety review needs to be performed. (<b>Note:</b> This step may be eliminated if going directly to the Laboratory Environmental, Safety and Health Committee [LESHC]).</p> <p><b>Note:</b> Standard-catalog cryogenic components and equipment and commercial vessels built to industry standards and used exclusively for storage need to be verified by Safety Engineering. Replacement of a previously approved device with one that has the same form, fit, and function does not require additional approval.</p>
<b>Step 2</b>	<p>The Principal Investigator/Supervisor submits to the Safety Committee the design of the cryogenic system. Include the following:</p> <ul style="list-style-type: none"> <li>● Physical layout (i.e., key plans);</li> <li>● Piping and Instrumentation Drawings (P&amp;ID);</li> <li>● Design parameters, including: <ul style="list-style-type: none"> <li>○ Maximum design/Allowable working pressures;</li> <li>○ Pressure vessel, piping and component ratings;</li> <li>○ Total quantity of cryogenics;</li> <li>○ Maximum release rate: <ul style="list-style-type: none"> <li>■ heat flux;</li> <li>■ pressure relief capabilities;</li> </ul> </li> </ul> </li> <li>● Quench protection (if necessary);</li> <li>● Stress Analyses (may require Finite Element Analyses); <ul style="list-style-type: none"> <li>○ Must meet ASME Boiler &amp; Pressure Vessel code and piping code requirements;</li> </ul> </li> <li>● Materials used (and their suitability for cryogenic temperatures);</li> <li>● Oxygen deficiency hazard classification calculations;</li> <li>● Test plans/results;</li> <li>● Operating procedures/emergency procedures.</li> </ul> <p>If the system/design is sufficiently complex, additional analyses, such as Failure Modes and Effects Analysis, may be required. See the <a href="#">Hazard Analysis</a> Subject Area.</p>

<b>Step 3</b>	<p>The Committee reviews the design and verifies compliance with requirements/regulations.</p> <p>If any amount of liquid oxygen (LOX) will be used, refer to the section on <a href="#">Using Liquid Oxygen</a>.</p> <p>If any amount of flammable cryogens, such as liquid hydrogen (LH2) will be used, refer to the section on <a href="#">Using Flammable Cryogens</a>.</p>
<b>Step 4</b>	<p>Once all safety issues are resolved, the Committee Chairperson ensures findings are documented and recommends approval to the Department Chair/Division Manager.</p> <p><b>Note:</b> If an LESH review was requested by a departmental review committee, then the LESH Secretary notifies the appropriate committee coordinator.</p>
<b>Step 5</b>	<p>Supervisors ensure that personnel with the potential for exposure to cryogens have completed training. See the <a href="#">Training and Qualifications</a> Web Site.</p>
<b>Step 6</b>	<p>The Building Manager or Designee ensures the Facility Use Agreements, Emergency Pre-plan response cards, and Emergency Hazard Placard are updated as necessary. See the <a href="#">Facility Use Agreements</a> and the <a href="#">Emergency Preparedness</a> Subject Areas for more information.</p>

## References

American Society of Mechanical Engineers (ASME) Boiler And Pressure Vessel Code

American Society of Mechanical Engineers (ASME) Code for Pressure Piping: Process Piping (B31.3)

American Society of Mechanical Engineers (ASME) Code for Pressure Piping: Refrigeration Piping and Heat Transfer Components (B31.5)

[Emergency Preparedness](#) Subject Area

[Facility Use Agreements](#) Subject Area

[Hazard Analysis](#) Subject Area

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# Management System: Worker Safety and Health

## Subject Area: Cryogenics Safety

# 1. Using and Designing Cryogenics **DRAFT**

Effective Date: **Sep 9, 9999**  
Last Modified: 06/08/2005  
02:37:20 PM

Subject Matter Expert:  
[Jim Durnan](#)

Management System Owner:  
[James Tarpinian](#)

| [SBMS Home Page](#) | [Top of Subject Area](#) | [Instructions](#) | [Definitions](#) |

## Applicability

This information applies to BNL staff and non-BNL staff doing work for BNL that will use cryogenic fluids and/or systems at BNL.

## Required Procedure

Cryogens, cryogenic fluids, and their associated systems are a significant hazard because of their intense cold and substantial gas production when warmed. Cryogens have very low-temperature boiling points and large gas expansion characteristics. Refer to the exhibit [Characteristics of Cryogens](#).

The extreme cold can cause serious tissue damage to staff, and can adversely change the properties of metals and other materials. Asphyxiation and overpressure hazards may be created by the production of large quantities of gas generated. These potential problems require that careful engineering attention be given to the storage, transfer, and use of cryogens.

Using and Designing Cryogens contains five subsections:

[1.1 Storage](#)

[1.2 Design](#)

[1.3 Material Usage](#)

[1.4 Transferring and Handling](#)

[1.5 Records and Documentation](#)

# 1.1 Storage

<b>Step 1</b>	<p>Store cryogenics in containers that have been designated by the manufacturer for holding cryogenic fluids. Such containers are made from materials that can withstand the rapid changes and extreme differences in temperature encountered in working with these liquids.</p> <p><b>Ordinary glassware must not be used</b> to store or transfer cryogenic liquids. All unprotected glass dewars must be wrapped with a heavy adhesive tape to prevent fragmentation and to provide a better gripping surface.</p>
<b>Step 2</b>	<p>Containers designed for cryogenic liquids are built to withstand normal operating pressures. However, all containers must be open or protected by a vent or other safety device that permits the escape of gas that has formed.</p> <p>Containers of cryogenic liquid <b>must never be closed</b> so that they cannot vent. Where a special vented stopper or venting tube is used, as on some small portable containers, the vent must be checked regularly to ensure it has not plugged with ice formed from water vapor condensed from the air.</p>
<b>Step 3</b>	<p>Use the liquid nitrogen buggy to store and transport liquid nitrogen on-site. See the exhibit <a href="#">Operating Instructions for Liquid Nitrogen Buggies</a>.</p> <p><b>Note:</b> The Supply &amp; Material Division is responsible for a program for preserving the safety of these vehicles through maintenance and repair; and the safety verification of incoming vendor-owned cryogenic storage units.</p>
<b>Step 4</b>	<p>Store cryogenic liquid dewars in well-ventilated areas. The release of gas can produce dangerously low concentrations of oxygen and must be evaluated. See the <a href="#">Oxygen Deficiency Hazards (ODH), System Classification and Controls</a> Subject Area for information.</p> <p>When working with cryogenics at temperatures less than 90°K, it is possible to develop a localized oxygen-enriched atmosphere from air condensation. Enhanced combustion is possible and appropriate controls are required (i.e., no smoking or hot work in area). Combustible materials that can absorb or collect liquefied oxygen (i.e., foam insulation) must be removed from the area.</p>

## 1.2 Design

<b>Step 1</b>	<p>Cryogenic systems require special design considerations. All designs must meet (the intent of) the appropriate requirements of the following:</p> <ul style="list-style-type: none"> <li>• Compressed Gas Association;</li> <li>• National Fire Protection Association (NFPA);</li> <li>• American Petroleum;</li> <li>• ASME Boiler and Pressure Vessel Code, Section VIII;</li> <li>• ASME Piping Code (B31.3).</li> </ul>
<b>Step 2</b>	<p>Provide protection for overpressurization for all pressurized systems. Pressure relief devices must not be isolated from the system it is protecting without approved controls.</p> <p>The outer wall of the vacuum space of a dewar or system must be provided with a burst disc or some other pressure relief mechanism to avoid overpressure in an inner vessel leak (The outer shell of a multi-shell cryogenic vessel must be designed for at least 15-psig external pressure).</p>

## 1.3 Material Usage

<b>Step 1</b>	<p>The materials used in cryogenic systems must have the appropriate physical properties to qualify them for use at these extremely low temperatures. Some acceptable materials are</p> <ul style="list-style-type: none"> <li>• Aluminum;</li> <li>• Series 300 Stainless steels (such as 304, 316);</li> <li>• Copper;</li> <li>• Brass;</li> <li>• Fiberglass (i.e., G-10).</li> </ul> <p>The <a href="#">National Institute of Standards and Technology (NIST), Cryogenic Technologies Group' Material Properties</a> Web Site lists material properties at cryogenic temperatures.</p> <p style="text-align: center;"><b>Caution</b></p> <p>Materials that are subject to brittle fracture, such as ordinary carbon steels, lose their ductility at low temperature and are <b>strictly prohibited from use</b>.</p>
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<b>Step 2</b>	<p>Materials susceptible to hydrogen attack and hydrogen embrittlement must not be used in hydrogen service. Avoid the following materials:</p> <ul style="list-style-type: none"> <li>• Titanium;</li> <li>• Maraging steels;</li> <li>• SA-517 (or similar heat-treated steels);</li> <li>• Series 400 Stainless steels;</li> <li>• MIL-S-16216, and precipitation-hardened stainless steels.</li> </ul> <p><b>Note:</b> See NSS 1740.16, "NASA Safety Standard for Hydrogen and Hydrogen Systems," for more information on hydrogen service.</p>
<b>Step 3</b>	<p>Cryogenic temperatures also give rise to unique insulation problems and to considerations of expansion and contraction. Carefully review the complexity of these problems, and the special safety requirements.</p>

## 1.4 Transferring and Handling

<b>Step 1</b>	<p>The extremely low temperatures of cryogenic liquids can quickly produce frostbite. The gases released from are also extremely cold and can produce frostbite and permanently damage delicate tissues, such as the eyes by only brief exposure.</p> <p>Eye protection must be used whenever handling or transferring cryogenics: Splash goggles and a combination splash goggles and full-face shield should be used when transferring liquids to an open container.</p> <ul style="list-style-type: none"> <li>• All parts of the body must be protected from uninsulated pipes or vessels containing cryogenic liquids; the extremely cold metal may stick fast to the skin and result in torn flesh when the skin is withdrawn.</li> <li>• Tongs must always be used to withdraw objects immersed in liquid.</li> <li>• In addition to the hazard of frostbite, objects that are soft and pliable at room temperatures usually become very hard and brittle at the temperatures of these liquids and are very easily broken.</li> </ul>
<b>Step 2</b>	<p>Boiling and splashing of cryogenic liquids always occurs when charging a warm container or when inserting warm objects into the liquid. Perform these operations slowly to minimize boiling and splashing.</p>

<b>Step 3</b>	<p>Wear gloves when handling objects that are in contact with cryogenic liquid. Gloves should be designed to provide protection from cryogenics (see the <a href="#">Personal Protective Equipment</a> Subject Area for information). Gloves should either be designed to prevent cryogenics from flowing into the glove, or be loose fitting so the glove can be easily be shaken off in accidental contact with cryogenics.</p> <p><b>Note:</b> When handling liquids in open containers, it is advisable to wear high-top shoes. Trousers (which should be cuffless, if possible) should be worn outside the shoes.</p>
<b>Step 4</b>	<p>Move dewars filled with cryogenic liquids cautiously. Many dewars are somewhat unstable and movement over doorways and other floor obstructions can be hazardous. If small quantities of inert cryogenics are being moved on-site, then the dewar must not be stored in the passenger compartment of vehicles. The dewar must be secured from tipping, and the vehicle windows must be fully open to prevent concentration of gasses.</p> <p>If a dewar must be rigged, only devices designed to lift the dewar must be used. Controls must be in place to protect staff in the area in case of a failure.</p>
<b>Step 5</b>	<p>All shipments on-site must comply with the <a href="#">BNL On-site Transfer/Safety Assessment Form</a> as defined in the <a href="#">Transfer of Hazardous Materials Onsite</a> Subject Area.</p> <p>Any shipments off-site must comply with the Department of Transportation (DOT) regulations for the transport of hazardous materials.</p> <p>Liquid nitrogen is typically transferred on-site using LN2 buggies. The user of the buggy is responsible for ensuring it is in good working order (for example, tire failure is common if the tires are not moved occasionally due to routine freezing). Post a copy of the operating procedure on the buggy (see the exhibit <a href="#">Operating Instructions for Liquid Nitrogen Buggies</a>).</p>

## 1.5 Records and Documentation

<b>Step 1</b>	<p>Maintain a log for all dewars with a capacity of 100 liters and larger. Up-to-date schematics and operating instructions of cryogenic systems should also be maintained and posted near the equipment. The records and documents must indicate the following:</p> <ul style="list-style-type: none"> <li>• Individual responsible for the dewar;</li> <li>• Date, quantity, and type of all fillings;</li> <li>• A qualitative history of the effectiveness of the insulating vacuum and/or boil-off rate and any corrective actions that have been taken.</li> </ul>
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**Step 2**

Postings, barriers, and guards must be used to warn and protect staff from contact with uninsulated cryogenic piping and components. The exhibit [Extreme Low Temperatures Caution](#) gives an example of a caution posting.

It is recommended that the following symbol be placed on the posting to identify the use of cryogenics:



## References

NSS 1740.16, "NASA Safety Standard for Hydrogen and Hydrogen Systems"

[National Institute of Standards and Technology \(NIST\), Cryogenic Technologies Group' Material Properties](#) Web site

[Oxygen Deficiency Hazards \(ODH\), System Classification and Controls](#) Subject Area

[Personal Protective Equipment](#) Subject Area

[Transfer of Hazardous Materials Onsite](#) Subject Area

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Management System: [Worker Safety and Health](#)

Subject Area: [Cryogenics Safety](#)

## Plugged Dewars

Effective Date:

### Evaluating Plugged Dewars

Occasionally a dewar will become plugged with ice, and a potential high-pressure hazard can be created. Such plugs are most common in portable dewars in which the liquid vents directly to the atmosphere, especially if left outside (exposed to the elements) or kept in a high humidity environment. The rate of the pressure buildup in a plugged dewar depends upon several factors:

1. Volume of liquid in the dewar;
2. Type of liquid;
3. Rate of heat leak to the liquid.

Because of these variables, the rate of pressure build-up in a plugged dewar cannot be predicted. However, for a plugged dewar and the loss of vacuum insulation, rapid failure can be expected. In such an event, staff should be immediately withdrawn and the area rendered as free from secondary risk as possible (e.g., other pieces of equipment which could be damaged by dewar rupture). A representative of any of the following groups on-site must be contacted immediately for assistance in removing the plug:

- Cryogenic Group in the Collider-Accelerator Department;
- Cryogenic Safety Committee;
- Trained employees of the Department/Division.

The initial evaluation of a plugged dewar should focus on the history of the dewar as determined from the operating personnel and the log when available. The following items should be explored:

1. How long has the dewar been plugged?
2. Obtain a schematic of the system and investigate possible ways of relieving the over pressure via system piping or institute corrective procedures if they already exist.
3. How long since liquid was last transferred from the dewar?

4. How long since the dewar was last filled?
5. How many liquid transfers have been made from the dewar?
6. Can the dewar pressure be determined? (Care must be exercised since the gauge pressure may not read actual dewar pressure, depending on location of ice plug. Additionally, the dewar may not have a pressure gauge.) See below for information on removing plugs.

## Removing Plugs

Only **trained** individuals associated with the Cryogenic Group (C-A Department), members of the Cryogenic Safety Committee, or those individuals designated by the Department/Division, after receiving the proper training, remove plugs.

### WARNING

### DO NOT USE ON FLAMMABLE CRYOGENS OR LIQUID OXYGEN

#### A. Fill Line Plug

Plugs can be removed by introducing heat with a warm metal rod placed in the fill line or by flowing warm helium gas through a tube inserted in the fill line. When attempting to remove a plug, observe the following precautions:

- Protect face and other bare skin from rapid release of cold gas;
- Place a barrier between the technician and the dewar. (A blast mat would be satisfactory);
- Keep face and hands away from the area where the cold gas will vent when the plug is removed.

To remove a plug

- a. Connect a 1/4" O.D. copper tube to a regulated supply of pure helium gas. Assume that the tube O.D. is less than or at maximum equal to 1/2 the diameter of the dewar neck. Adjust the tube size accordingly if 1/4" is too large. This precaution ensures the tube will not be pushed out, due to piston force, when the plug is cleared.
- b. Set the regulator at 3-5 psi to establish a purge flow through the tube.
- c. Gently insert the tube into the dewar neck until it comes in contact with the plug (obstruction); this will introduce heat into the plugged area. Mark the initial insertion position of the tube to measure the insertion depth-change, and therefore, monitor the removal progress.
- d. Alternately a 1/4" O.D., or other size as described above, solid copper, brass, or stainless steel rod could be gently inserted against the plug. The solid rod could be periodically removed for warming to accelerate melting.
- e. Continue to purge with the warm gas or use the solid rod until the dewar begins to show

signs of venting (indicated by the release of cold gas), or the 1/4" tube/rod slides freely down the dewar's neck past its initial insertion position.

- f. Take precautions to prevent the rod from falling into the dewar when the obstruction is cleared.

## **B. Transfer Line Plug**

If a plug exists in an easily removed transfer line, disconnect the line from the dewar, and let it warm up. If not, disconnect the line from the dewar, secure the line and ensure ends are directed away from harm, and pressure the transfer line to 3 psig with helium gas. This method will usually melt the ice plug. After the plug is removed, pump and purge the line to remove moisture and other contaminants.

## **C. Dewar Vent Line Plug**

If a plug exists in the dewar normal vent or gas shield vent, the pressure can be relieved by bleeding the pressure through the fill connection. Then pressurize the plugged vent to 5 psig with warm helium gas. After the plug is removed, resume normal venting.

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# CAUTION



## Personnel Injury Extreme Low Temperatures

- Cryogenic materials in use
  - Frost Bite
  - Oxygen Deficiency Hazard
- Use Protective Equipment
  - Eye Protection
  - Gloves

**Contact**

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## **DRAFT** Subject Area: Cryogenics Safety

Effective Date: **Sep 9, 9999**[Last Modified:](#)  
[06/23/2005 4:52 PM](#)Subject Matter Expert:  
[Jim Durnan](#)Management System Owner:  
[James Tarpinian](#)

### Introduction

Cryogenics, cryogenic fluids, and their associated systems are a significant hazard because of their intense cold and substantial gas production when warmed. The extreme cold (temperatures at or less than 170° Kelvin) can cause tissue damage to personnel and bring about changes in the properties of metals and other materials. Asphyxiation and overpressure hazards may be created by the production of large quantities of gas. These potential problems require that careful attention be given to the storage, transfer, and use of cryogenics to ensure the safety of personnel working.

This subject area describes the procedures for

- Establishing the safety requirements for using cryogenics, cryogenic fluids, and their associated systems;
- Reviewing cryogenic safety matters associated with cryogenic uses at the Laboratory;
- Using liquid oxygen and flammable cryogenics.

### Contents

## Section

## Overview of Content (see section for full process)

### [1. Using and Designing Cryogenics](#)

- Store cryogenics in specially designed containers in well ventilated areas.
- Design cryogenic systems to ensure safe operation.
- Use personal protective equipment.
- Move dewars cautiously.
- Maintain log for dewars with a capacity of 100 liters and larger.
- Use posting, barriers, and guards to warn and protect staff.

### [2. Cryogenic Safety Review](#)

- Inform Department/Division that a cryogenic safety review is needed.
- Submit to Safety Committee the design of the cryogenic system.
- Review design and verify compliance with requirements/regulations.
- Resolve issues.

### [3. Using Flammable Cryogens](#)

- Request reviews and submit recommendations for approvals.
- Ensure provisions are established for delivery of flammable cryogens.
- Follow requirements for transferring flammable cryogens over Laboratory roads.

### [4. Using Liquid Oxygen](#)

- Request reviews and submit recommendations for approval.
- Ensure provisions are established for delivery of liquid oxygen (LOX).
- Follow requirements for transferring LOX over Laboratory roads.

## [Definitions](#)

## Exhibits

[Characteristics of Cryogenics](#)

[Extreme Low Temperatures Caution](#)

[Liquid Oxygen and Flammable Cryogenics Safety Requirements](#)

[Operating Instructions for Liquid Nitrogen Buggies](#)

[Plugged Dewars](#)

## Forms

None

## Training Requirements and Reporting Obligations

This subject area contains training requirements. See the [Training and Qualifications](#) Web Site.

This subject area does not contain reporting obligations.

## References

American Society of Mechanical Engineers (ASME) Boiler And Pressure Vessel Code

American Society of Mechanical Engineers (ASME) Code for Pressure Piping: Process Piping (B31.3)

American Society of Mechanical Engineers (ASME) Code for Pressure Piping: Refrigeration Piping and Heat Transfer Components (B31.5)

Compressed Gas Association Pamphlet, G-4.1 "Cleaning Equipment for Oxygen Service"

[National Institute of Standards and Technology \(NIST\), Cryogenic Technologies](#)

[Group' Material Properties](#) Web site

[Emergency Preparedness](#) Subject Area

[Engineering Design](#) Subject Area

[ESH Standard 4.11.0, Installation of Flammable Gas Systems \(Experimental and Temporary Installations\)](#)

[ESH Standard 4.12.0, Special Precautions for Locations Containing Flammable Atmospheres](#)

[Facility Use Agreements](#) Subject Area

[Hazard Analysis](#) Subject Area

NSS 1740.16, "NASA Safety Standard for Hydrogen and Hydrogen Systems"

National Fire Protection Association Standard No. 50B, "Liquefied Hydrogen Systems at Consumer Sites"

OH&S Guide 5.1.0, "Nonflammable Cryogenic Liquids"

[Operational Readiness Evaluation \(ORE\)](#) Subject Area

[Oxygen Deficiency Hazards \(ODH\), System Classification and Controls](#) Subject Area

[Personal Protective Equipment](#) Subject Area

[Training and Qualifications](#) Web Site

[Transfer of Hazardous Materials Onsite](#) Subject Area

[Work Planning and Control for Experiments and Operations](#) Subject Area

## Standards of Performance

All staff and guests shall comply with applicable Laboratory policies, standards, and procedures, unless a formal variance is obtained.

Managers shall analyze work for hazards, authorize work to proceed, and ensure that work is performed within established controls.

All staff and users shall identify, evaluate, and control hazards in order to ensure that work is conducted safely and in a manner that protects the environment and the public.

All staff and users shall ensure that they are trained and qualified to carry out their assigned responsibilities, and shall inform their supervisor if they are assigned to perform work for which they are not properly trained or qualified.

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## Lessard, Edward T

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**Subject:** Updated: LESHHC 05-07, Review of Committee Procedure and Cryo SA  
**Location:** Berkner, Room C

**Start:** Tue 8/16/2005 1:30 PM  
**End:** Tue 8/16/2005 3:00 PM

**Recurrence:** (none)

**Meeting Status:** Accepted

**Required Attendees:** Travis, Richard J; Durnan, James T; Alforque, Rodulfo; Glenn, Joseph W; Kane, Steven F; Lessard, Edward T; Mortazavi, Payman; Rehak, Margareta L; Sidi-Yekhlef, Ahmed; Wu, Kuo-Chen

**Optional Attendees:** Petricek, Robert J; Bernholc, Nicole M; Beuhler, Robert; Costa, Raymond; Gill, Ronald L; Ginsberg, Theodore; Gunther, William E; Kahnhauser, Henry F; Lee, Robert J; Bebon, Michael J; Tarpinian, James; Williams, Patricia; Ellerkamp, John J; Greves, Linda E; Gmur, Nicholas

**This meeting was rescheduled from 7/21.**  
**Rich**

All,

The purpose of this meeting is to review the draft Cryogenic Safety Subject Area [https://sbms.bnl.gov/draft/subjarea/164/164\\_SA.cfm](https://sbms.bnl.gov/draft/subjarea/164/164_SA.cfm) and the cryogenic aspects of the draft LESHHC Guidelines document (Rev 4B) for consistency and accuracy. Attached below is the latest version of the LESHHC Guidelines



LESHHC  
ines DRAFT 4B

### As background:

We had a meeting in 2004 (LESHHC 04-01) to develop guidelines for the Committee. The documents that were reviewed were:

- The CryoFab Co. Design Guidelines
- CERN Safety Code D2, "Pressure Equipment", Rev 2
- ESH 1.4.1, "Pressurized Systems for Experimental Use, <https://sbms.bnl.gov/SBMSearch/Id/Id08/Id08d131.htm>

The Draft LESHHC Guidelines Document and the draft List of LESHHC Control Levels were developed from this meeting. Everyone reviewed Revision 4 (LESHHC 05-06, 6/8/05 email). We are now up to Rev 4B.

Ed had also transmitted the draft Cryo Safety Subject Area for input. See the attached email for background:



FW: Cryogenic  
SBMS

### **Issues for Discussion at the meeting:**

- **What types of cryogenic systems and equipment will the Committee review?**
  - Per the Cryogenic Safety Subject Area, "if this is a new cryogenic system, custom-built cryogenic equipment, or the cryogenic system is designed, built or modified at BNL or by the experimenter's

home institution, the Laboratory Environmental, Safety and Health Committee (LESHC) will perform the review." and "standard-catalog cryogenic components and equipment and commercial vessels built to industry standards and used exclusively for storage (i.e., dewars) need to be verified by Safety Engineering. Replacement of a previously approved device with one that has the same form, fit, and function does not require additional approval."

- At some point, a bunch of commercially available cryo components make a cryo system.....
- There has been some past Subcommittee discussion about limiting the exclusion to commercial dewars
- Most of our reviews have involved custom cryo components, however, LESHC 05-03 reviewed a catalog item, an isopentane cooler and liquid xenon generator. LESHC 04-04 (LACARA) had a commercially available cryocooler,
- **Should we adopt "de minimus" review criteria?**
  - In LESHC 04-01 we talked about using the following from Section 2 of ESH 1.4.1, Pressure Safety, "In addition, the following classifications are not considered to be within the scope of this Guide, although the principles of the ASME Code shall be followed:
    - Vessels having an internal or external operating pressure not exceeding 15 psi with no limit on size. (Note: See [Sect. IV.I.](#))
    - Vessels having both an inside diameter not exceeding six inches, and containing a maximum stored energy of 2000 joules.
  - The CERN "Pressure Equipment" procedure has a 0.5 bar (gauge)
- **Sections 3 (Flammable Cryogens) and 4 (Using Liquid Oxygen) of the draft Cryogen Safety Subject Area require full LESHC review of new flammable cryogen systems and Subcommittee review of slightly modified or systems being returned to service. Storage of flammable cryogens also requires review.**
- **The CERN procedure and ESH 1.4.1 are very detailed/prescriptive. This level of detail is not prescribed in the draft Cryogenic Safety and the draft Pressure Safety Subject Areas. Typically its a general statement to comply with the Code. ....**

[Jim,](#)

Plan on a short (~10 minute) presentation to the Committee summarizing the Cryogenic Safety Subject Area with an emphasis on the "issues for discussion", as applicable.

[Nicole, Bob B., Ray, Ron, Ted, Bill, Henry and Bob L.,](#)

As a Cryo Subcommittee Meeting, this notice is for your info only. However, please feel free to comment on the attached documents or attend, if you have an interest.

Thanks,  
Rich Travis  
LESHC Secretary

# LESHC 1.0 (DRAFT 4.0B)

## Guidelines and R2A2s for the Laboratory Environmental, Safety and Health Committee and the Cryogenic Safety Subcommittee



Prepared by: \_\_\_\_\_

Edward T. Lessard  
Chair of LESHC

Approved by: \_\_\_\_\_

James Tarpinian,  
Assistant Laboratory Director for ESHQ

Date: \_\_\_\_\_

LESHC



REGISTERED TO ISO 14001

DRAFT 4.0  
10/13/2005

## 1. Purpose and Scope

1.1. The Laboratory Environmental, Safety and Health Committee (LESHC) is composed of the Safety Assessment and the Cryogenic Safety Subcommittees (SAS and CSS, respectively).

1.2. This guideline provides instructions for the LESHC and its Subcommittees to carry out the review of ESH issues defined in Section 3.0.

## 2. Membership

2.1. Appointed by: Assistant Laboratory Director (ALD) for ESH & Quality.

2.2. Term: Three years

2.3. Members: The membership includes the Chairperson, term members and the Secretary.

2.3.1. The charge of the Committee and the current membership are located in the Laboratory's Committee Handbook at <https://sbms.bnl.gov/SBMSearch/LD/ld16/ld16t011.htm?parentID=2>

### NOTE:

Given the importance of the proceedings of this Committee to Laboratory operations, every effort should be made by members to attend, including schedule/work adjustments by their supervisors.

## 3. Roles, Responsibilities, Accountabilities and Authorities

### 3.1. Roles

3.1.1. The LESHC advises the operating organizations and the Assistant Laboratory Director for ESH & Quality on environmental impact, radiation, cryogenic safety and general safety and health matters associated with all Laboratory operations.

3.1.2. The LESHC provides independent assurance to the Assistant Laboratory Director for ESH & Quality that an in-depth analysis commensurate with the hazards involved has been performed and that a project or facility can function without undue risk to the environment, public or workers.

3.1.3. The SAS reviews facility authorization basis documents and proposed (or actual) variances to LESHC 1.0.a, "List of LESHC Control Levels Used in the Design of New or Modified Facilities". On the basis of this review, the LESHC makes a recommendation to the Deputy Director for Operations (DDO) in accordance with the "Accelerator Safety" Subject Area and Sections 3.2.4 and 3.2.5 below.

3.1.4. The CSS advises the operating organizations and the Assistant Laboratory Director for ESH & Quality on cryogenic safety.

### 3.2. Responsibilities

3.2.1. The LESHHC shall assist Department Chairs, Division Managers, Associate Laboratory Directors, Assistant Laboratory Directors (ALDs) and Deputy Directors who may call upon the Committee to review a specific ES&H-related issue. See NOTE.

#### NOTE:

The following are types of environmental and safety-related activities that the Committee may be called upon to review: audits or appraisals of Laboratory operations affecting safety (e.g., occupational safety and health, cryogenic safety, radiation safety, electrical safety, biosafety, etc.) or the environment and proposed corrective actions; safety-related operational event investigations; generic non-facility-specific unreviewed safety issues; criteria for environment, safety and health for the design and operations of facilities and equipment; plans for implementing operating safety limits; audit and inspection programs; training programs; plans for response to and recovery from major accidents in facilities; and proposed changes in the mode of operation or a facility modification that significantly increases either the probability or consequence of a bounding accident that was described in an authorization document.

3.2.2. The LESHHC shall review and make recommendations to the Assistant Laboratory Director for ESH & Quality on proposed changes or modifications to existing facilities significantly affecting safety and environmental protection.

3.2.3. The LESHHC shall ensure the laboratory control levels listed in LESHHC 1.0.a “List of Laboratory Control Levels Used in the Design of New or Modified Facilities” are applied in the review of new or modified facilities.

3.2.4. The LESHHC shall review all proposed (or actual) variances to LESHHC 1.0.a, “List of Laboratory Control Levels Used in the Design of New or Modified Facilities” and, with the concurrence of the Assistant Laboratory Director for ESH & Quality, make recommendations to the Deputy Director for Operations.

3.2.5. The SAS shall review and, with the concurrence of the Assistant Laboratory Director for ESH & Quality, make recommendations to the Deputy Director for Operations on new projects or facilities for which formal safety analyses are required.

3.2.6. The SAS shall review and recommend for approval all new or significantly revised facility authorization basis documents such as: Basis for Interim Operations, Safety Analysis Reports, Unreviewed Safety Issues, Unreviewed Safety Questions, Safety Assessment Documents, Accelerator Safety Envelopes, or Operational Safety Limits.

**CONDUCT OF OPERATIONS? RT HAS A CALL INTO FRANK MAROTTA.**

3.2.7. The CSS shall review documented designs of flammable and non-flammable cryogenic systems.

**Note:** In accordance with the Cryogenic Safety Subject Area, standard-catalog cryogenic components and equipment and commercial vessels built to industry standards and used exclusively for storage (i.e., dewars) need to be verified by Safety Engineering. Replacement of a previously approved device with one that has the same form, fit, and function does not require additional approval.

3.2.8. LESHC members shall attend meetings, perform independent, in-depth analysis of items presented related to their expertise and carry out site inspections when appropriate.

3.2.9. The LESHC Secretary shall notify the Assistant Laboratory Director for ESHQ and the Deputy Director for Operations about LESHC meetings and recommendations.

### 3.3. Accountabilities

3.3.1. The LESHC is accountable to the Assistant Laboratory Director for ESH & Quality to provide technical review of ES&H issues on new projects or facilities.

3.3.2. The LESHC is accountable to Deputy Directors, ALDs, Department Chairs and Division Managers who call upon the Committee to provide technical review of ES&H issues.

3.3.3. The LESHC is accountable to the science community to assist them to achieve BSA and organizational ES&H expectations in the design of their new or modified research facilities.

3.3.4. The LESHC is accountable to the support community to assist them to achieve BSA and organizational ES&H expectations in the design of their new or modified support facilities.

### 3.4. Authorities

3.4.1. The SAS shall recommend for approval authorization basis documents.

3.4.2. The SAS shall recommend for approval limiting conditions for operations.

3.4.3. The CSS shall approve testing, commissioning and/or operation of cryogenic systems.

## 4. Review Procedure

4.1. The LESHC Chairperson shall schedule meetings and convene the LESHC when appropriate.

4.1.1. The Chairperson may convene the full Committee, SAS or CSS, as dictated by the subject matter.

4.1.2. The Chairperson shall decide if the members participating in the review comprise the appropriate technical core for the matter to be deliberated. The Chair has the authority to appoint ad hoc members to the full committee or either subcommittee when specialized expertise is required.

4.2. Associate Laboratory Directors, Department Chairs or Division Managers can make requests for LESHHC reviews via the Project Manager or similar designee.

4.2.1. The role of a Project Manager is defined in the “R2A2 Profile Titles” Exhibit in the R2A2 Subject Area, [https://sbms.bnl.gov/sbmsearch/subjarea/58/58\\_SA.cfm?parentID=58](https://sbms.bnl.gov/sbmsearch/subjarea/58/58_SA.cfm?parentID=58)

4.3. The Project Manager shall forward requests for LESHHC evaluations to the Chair and provide any necessary documentation to aid in this evaluation.

4.4. If the request is appropriate for Committee review, the Chair of the LESHHC shall contact the Project Manager and schedule a meeting date.

#### 4.5. Document Submittals

4.5.1. All documents shall be submitted to the LESHHC Chairperson with a copy to the Secretary, preferably 2 weeks prior to the date of the meeting.

4.5.2. The Project Manager shall ensure all applicable department ESH&Q reviews are completed or in process prior to bringing the review to the full Committee or a Subcommittee.

4.5.3. For projects that do not require a Safety Assessment Document or Safety Analysis Report, the Project Manager shall complete the BNL Hazard Identification Tool at [http://www.bnl.gov/sbms\\_office/hid/](http://www.bnl.gov/sbms_office/hid/) and forward it to the LESHHC Chair.

4.5.4. For projects that do not require a Safety Assessment Document or Safety Analysis Report, the LESHHC Chair shall request document submissions based upon the responses indicated in the BNL Hazard Identification Tool that was completed by the Project Manager.

4.5.5.4.5.5 If a Cryogenic Safety Subcommittee review is required, then the vessels must meet ASME Boiler & Pressure Vessel code and piping code requirements and submissions to the Subcommittee shall consist of the following: **TBD – ADDITIONAL CRITERIA FROM CERN AND ESH STDS ?**

**ALSO ESRs?,**

- Physical layout
- Piping and instrumentation drawings
- Design parameters including:
  - Maximum design/Allowable working pressures
  - Pressure vessel, piping and component ratings
  - Total quantity of cryogenics
  - Maximum release rate:
    - Heat flux

- Pressure relief capabilities
- Quench protection description, if appropriate
- Stress analyses for custom made equipment
- Materials used and their suitability for cryogenic temperatures
- Oxygen deficiency hazard classification calculations as per the SBMS Subject Area

Test plans and results, if any Operating procedures Emergency procedures

- Experimental Safety Review(s), draft or final as available

4.5.6 The Chair shall ensure that adequate time is allocated for Committee review.

4.5.7 The Project Manager shall make a presentation to the full LESHHC or the appropriate Subcommittee and submit any additional requested documents for review.

## 5. Decision Making Process

5.1. A quorum shall consist of a simple majority of the impaneled Committee or Subcommittee members, which does not include the Secretary.

5.2. A decision shall consist of a simple majority vote of the Committee members in attendance, including any impaneled ad hoc members.

5.3. Decisions can be made using an email voting system.

5.4. Committee members shall abstain from voting if there is a real or apparent conflict of interest.

5.5. If there are any dissenting votes, then a minority statement may be recorded by the LESHHC Secretary along with the decision.

## 6. Documentation

6.1. The LESHHC Secretary or designate shall prepare meeting minutes and publish them as a minutes to be signed by the LESHHC Chair and the ALD for ESHQ with copies to the LESHHC members, the meeting requestor and the ALD for ESHQ.

6.2. The written minutes and materials used during the presentations shall be kept in a dedicated file under the control of the LESHHC Secretary. (Document retention periods will conform to the requirements of the "Records Management" Subject Area. Copies may be kept on the internet.

6.3.Recommendations by the LESHHC that require response by BNL management or staff shall be defined as sequentially numbered Action Items in the meeting minutes.

6.4.The master list of Action Items and status shall be kept in a dedicated file under the control of the LESHHC Secretary or in ATS.

6.5.The Project Manager shall document the closure of open Action Items to the LESHHC Chair with a copy to the Secretary. Documentation of closure can be in a BNL Memorandum, email or through entries in ATS.

6.6.The LESHHC Secretary shall forward the closure documentation to the Committee members for their information.

## 7.Attachments

7.1.[LESHHC 1.0.a, “List of Laboratory Control Levels Used in the Design of New or Modified Facilities”](#)

# LESHC 1.0.a (DRAFT 3.0)

## List of LESHC Control Levels Used in the Design of New or Modified Facilities



Prepared by: \_\_\_\_\_  
Edward T. Lessard  
Chair of LESHC

Approved by: \_\_\_\_\_  
James Tarpinian,  
Assistant Laboratory Director for ESHQ

Date: \_\_\_\_\_

LESHC



REGISTERED TO ISO 14001

Draft 3.0  
10/13/2005

## 1. Purpose and Scope

This document summarizes the control levels used by the Laboratory Environmental, Safety and Health Committee in the review of designs, SARs, ASEs or SADs related to new or modified facilities, or to cryogenic systems.

## 2. List of Control Levels

Control Level	Applicability	Source of Limit	Reason for Control Level
Less than 25 mrem in one year to individuals in other BNL Departments or Divisions adjacent to an accelerator or nuclear facility.	New or modified facilities that emit radiation or radioactive airborne materials.	BNL LESHHC records.	To ensure that non-trained personnel are kept below 100 mrem in one year from incidental exposure while working at BNL.
Less than 5 mrem per facility in one year to a person located at the site boundary	New or modified facilities that emit radiation or radioactive airborne materials.	BNL LESHHC records.	DOE established 25 mrem per year limit in the 1980s for the general public that require DOE permission to exceed. The LESHHC apportioned 5 mrem per new or modified BNL facility.
Groundwater concentration must not be greater than 5% of the Drinking Water Standard.	Facilities that cause radioactive liquids to enter or to be created directly in ground water.	SBMS Subject Area for Accelerator Safety.	EPA established rules that require offsite drinking water concentration to not result in 4 mrem or greater to an individual in one year. This BNL control level helps ensure the EPA rule can be met for multiple sources of groundwater contamination on site.

Airborne effluents from facilities shall not result in a dose that exceeds 0.1 mrem in one year to a person at the site boundary.	Facilities that emit airborne radioactive materials.	SBMS Subject Area Radioactive Emissions.	EPA established rules that require airborne emissions to be continuously monitored if they exceed 0.1 mrem to an individual in one year. This LESHC control level helps ensure the EPA rule can be met.
Less than 500 mrem planned or designed in one year to a trained radiation worker.	New or modified facilities.	BNL RadCon Manual Paragraph 211.	The BNL limit is less than 1250 mrem in one year to a trained BNL employee, guest or user. To help ensure this limit is not exceeded, the LESHC asks that facilities be planned or designed to 500 mrem per year or less to an individual.
Maximum radionuclide concentration less than 50% of the DWS and maximum tritium concentration less than 25% of the DWS at BNL sanitary sewer Outfall #1, caused by liquid discharges from a facility averaged over a 30-day interval.	All facilities that emit tritium liquid effluents to the sanitary sewer.	SBMS Subject Area Liquid Effluents.	BNL has chosen to limit the tritium in the sanitary system below the Drinking Water Standard out of concern for stakeholders. Justifications are required if a facility cannot meet this control level.
No more than 20 mrem per fault at an accelerator facility to an individual in an uncontrolled area.	All new or modified accelerators	BNL LESHC	This is guidance for the design of accelerator facilities since these facilities may be large and encompass areas such as roadways in uncontrolled areas

Neutron quality factors shall be doubled for designs at new facilities when neutron energy is known. If energy is unknown, then a quality factor of 20 shall be used.	All facilities.	BNL RadCon Manual Paragraph 125.	Design analyses based on these neutron quality factors are intended to be used to estimate the additional construction cost that would result if the neutron quality factor was increased. The results of these analyses shall be used to ascertain the economic feasibility for incorporating such modifications in the final design.
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### 3. References

BNL SBMS  
BNL RadCon Manual  
LESHC Records

# Definitions: Cryogenics Safety **DRAFT**

Effective Date:

Point of Contact: [Jim Durnan](#)

Term	Definition
brittle fracture	The material phenomena that at low temperatures, the material catastrophically fails at stresses typically less than yield stresses. These materials usually have a Body Centered Cubic (BCC) lattice structure. Materials with Face Centered Cubic (FCC) lattice structures, typically show ductility at cryogenic temperatures.
cryogens	Fluids that exhibit extremely low (less than 170°K) boiling-point temperatures. These include liquefied atmospheric gases, such as nitrogen, helium, argon and neon, hydrogen, and oxygen.
cryostat	An engineered device designed to provide thermal insulation for a cryogenic system. Typically, a vacuum vessel surrounding the cryogenic (cold) mass such as a magnet or detector.
dewar	Container for storage or transport of cryogenic liquids.  Typically it has a vacuum jacket for thermal insulation.
engineered system	A cryogenic system for an experimental device containing a refrigeration source (closed cycle refrigerator or bulk storage) that has been designed with the appropriate safety features.
flammable cryogens	Liquefied hydrogen and oxygen. Liquid Oxygen is included due to its ability to effect combustion rates.
LH2	Liquid Hydrogen
LHe	Liquid Helium
LOX	Liquid Oxygen
LN2	Liquid Nitrogen

plug

Contamination (usually in the form of ice) that can act as a pressure boundary in either a transfer line or dewar opening.

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